What is claimed is:

1. A highly bandwidth-efficient communications method, comprising:

a) receiving at a base station, during a first time period, a first spread signal comprising a first data signal redundantly spread over a plurality of discrete tones in accordance with a first spreading code;

b) despreading the first spread signal received at the base station, using despreading codes that are determined adaptively based on at least one characteristic of the received first spread signal;

c) spreading a second data signal at the base station, using second spreading codes derived from the said despreading codes, said second spreading codes redundantly spreading the second data signal over a plurality of discrete tones, to form a second spread signal; and

d) transmitting said second spread signal during a second time period.

2. The highly bandwidth-efficient communications method of claim 1, wherein both the first and the second spread signals have the spectral form of a discrete multitone signal.

3. The highly bandwidth-efficient communications method of claim 1, wherein said despreading step comprises multiplication of a complex number representation of the despreading codes times a complex number representation of the first spread signal.

4. The highly bandwidth-efficient communications method of claim 1, wherein said spreading step comprises multiplication of a complex number representation of the second spreading codes times a complex number representation of the second data signal.

5. The highly bandwidth-efficient communications method of claim 1, wherein said despreading step comprises determination of complex despreading code values which are then multiplied with a complex number representation of the received signals, resulting in an estimate of the first data signal.

6. The highly bandwidth-efficient communications method of claim 1, wherein the base station has a multi-element antenna array receiving the first spread signal, and the despreading step further comprising:

despreading the first spread signal with an adaptive despreading code that is based on the characteristics of the received spread signal, where a given element of the spreading code corresponds to the combination of a given one of said multi-element antennas and a given one of said discrete tones;

whereby said despreading step determines spatial and spectral components of the first spread signal in the same mathematical operation.

7. The highly bandwidth-efficient communications method of claim 6, wherein said despreading step adaptively positions the spatial direction of receive sensitivity towards a desired signal source and diminishes receive sensitivity from interfering sources.

8. The highly bandwidth-efficient communications method of claim 1, wherein the base station has a multi-element antenna array transmitting the second spread signal, and wherein said spreading step adaptively positions transmitted signal energy of said second spread signal towards a source of said first spread signal and adaptively diminishes transmitted signal energy towards interferers.

9. The highly bandwidth-efficient communications method of claim 1, wherein said first period and said second period comprise a time division duplex period.

10. The highly bandwidth-efficient communications method of claim 1, wherein said base station receives interference signals from interfering signal sources along with said first spread signal, said despreading step further comprising:

adaptively reducing the interference signals by adaptively adjusting said despreading codes to improve a signal quality characteristic of the received signal.

11. A highly bandwidth-efficient communications method, comprising:

a) receiving at a base station having a multi-element antenna array, during a first time period, a first spread signal comprising a first data signal redundantly spread over a plurality of discrete tones in accordance with a first spreading code;

b) despreading the first spread signal received at the base station, using despreading codes that are determined adaptively based on at least one characteristic of the first spread signal received at least two of the antenna elements of the said array;

c) spreading a second data signal at the base station, using second spreading codes derived from the said despreading codes, said second spreading codes redundantly spreading the second data signal over a plurality of discrete tones and over at least two of the antenna elements of the said array, to form a second spread signal that is thereby both spectrally and spatially spread; and

d) transmitting said second spread signal during a second time period.

12. The highly bandwidth-efficient communications method of claim 11, wherein both the first and the second spread signals have the spectral form of a discrete multitone signal transmitted on multiple antennas in said array.

13. The highly bandwidth-efficient communications method of claim 11, wherein said despreading step comprises multiplication of a complex number representation of the despreading codes times a complex number representation of the first spread signal.

14. The highly bandwidth-efficient communications method of claim 11, wherein said spreading step comprises multiplication of a complex number representation of the second spreading codes times a complex number representation of the second data signal.

15. The highly bandwidth-efficient communications method of claim 11, wherein said despreading step comprises determination of complex despreading code values which are then multiplied with a complex number representation of the received signals, resulting in an estimate of the first data signal.

16. The highly bandwidth-efficient communications method of claim 11, the despreading step further comprising:

despreading the first spread signal with an, adaptive despreading code that is based on the characteristics of the received signals, where a given element of the spreading code corresponds to the combination of a given one of said antenna elements and a given one of said discrete tones;

whereby said despreading step determines spatial and spectral elements of the first spread signal in the same mathematical operation.

17. The highly bandwidth-efficient communications method of claim 16, wherein said despreading step adaptively positions the spatial direction of receive sensitivity towards a desired signal source and diminishes receive sensitivity from interfering sources.

18. The highly bandwidth-efficient communications method of claim 11, wherein said spreading step adaptively positions transmitted signal energy of said second spread signal towards a source of said first spread signal and adaptively diminishes transmitted signal energy towards interferers.

19. The highly bandwidth-efficient communications method of claim 11, wherein said first period and said second period comprise a time division duplex period.

20. The highly bandwidth-efficient communications method of claim 11, wherein said base station receives interference signals from interfering signal sources along with said first spread signal, said despreading step further comprising:

adaptively reducing the interference signals by adaptively adjusting said despreading codes to improve a signal quality characteristic of the received signal.

21. A highly bandwidth-efficient communications method, comprising:

a) receiving at a base station having a multi-element antenna array, during a first time period, a first spread signal comprising a first data signal redundantly spread over a plurality of discrete tones in accordance with a first spreading code;

b) despreading the first spread signal received at the base station, using despreading codes that are determined adaptively based on at least one characteristic of the first spread signal received at least two of the antenna elements of the said array, where a

given component of the spreading code is associated with the combination of a given one of said antenna elements and a given one of said discrete tones;

c) spreading a second data signal at the base station, with second spreading codes derived from the said despreading codes, said second spreading codes redundantly spreading the second data signal over a plurality of discrete tones and over at least two of the antenna elements of the said array, to form a second spread signal that is thereby both spectrally and spatially spread; and

d) transmitting said second spread signal during a second time period.

22. The highly bandwidth-efficient communications method of claim 21, wherein both the first and the second spread signals have the spectral form of a discrete multitone signal transmitted on multiple antennas in said array.

23. The highly bandwidth-efficient communications method of claim 21, wherein said despreading step comprises multiplication of a complex number representation of the despreading codes times a complex number representation of the first spread signal.

24. The highly bandwidth-efficient communications method of claim 21, wherein said spreading step comprises multiplication of a complex number representation of the second spreading codes times a complex number representation of the second data signal.

25. The highly bandwidth-efficient communications method of claim 21, wherein said despreading step determines values of complex despreading codes which are then multiplied with a complex number representation of the received signals, resulting in an estimate of the first data signal.

26. The highly bandwidth-efficient communications method of claim 21, wherein said despreading step adaptively positions the spatial direction of receive sensitivity towards a desired signal source and diminishes receive sensitivity from interfering sources.

27. The highly bandwidth-efficient communications method of claim 21, wherein said spreading step adaptively positions transmitted signal energy of said second spread signal towards a source of said first spread signal.

28. The highly bandwidth-efficient communications method of claim 21, wherein said despreading step comprises treating spatial and spectral components of the first spread signal independent of their spatial or spectral characteristics.

29. The highly bandwidth-efficient communications method of claim 21, wherein said first period and said second period comprise a time division duplex period.

30. The highly bandwidth-efficient communications method of claim 21, wherein said base station receives interference signals from interfering signal sources along with said first spread signal, said despreading step further comprising:

adaptively reducing the interference signals by adaptively adjusting said despreading codes to maximize the signal quality of the received signal.

31. A highly bandwidth-efficient communications method, comprising:

a) receiving at a base station, in a first propagation direction, during a first time period, a first spread signal comprising a first data signal redundantly spread over a plurality of discrete tones in accordance with a first spreading code;

b) despreading the first spread signal received at the base station, using despreading codes that are determined adaptively based on at least one characteristic of the first spread signal received at the base station in said first propagation direction;

c) spreading a second data signal at the base station, with second spreading codes derived from said despreading codes, said second spreading codes based on substantial channel reciprocity between said propagation direction and the reverse propagation direction, the second spreading codes redundantly spreading the second data signal over a plurality of discrete tones, to form a second spread signal; and

d) transmitting said second spread signal in said reverse propagation direction during a second time period.

32. The highly bandwidth-efficient communications method of claim 31, wherein both the first and the second spread signals have the spectral form of a discrete multitone signal.

33. The highly bandwidth-efficient communications method of claim 31, wherein said despreading step comprises multiplication of a complex number representation of the despreading codes times a complex number representation of the first spread signal.

34. The highly bandwidth-efficient communications method of claim 31, wherein said spreading step comprises multiplication of a complex number representation of the second spreading codes times a complex number representation of the second data signal.

35. The highly bandwidth-efficient communications method of claim 31, wherein said despreading step determines values of complex despreading codes which are then multiplied with a complex number representation of the received signals, resulting in an estimate of the first data signal.

36. The highly bandwidth-efficient communications method of claim 31, wherein the base station has a multi-element antenna array receiving the first spread signal, the despreading step further comprising:

> despreading the first spread signal with a unitary, adaptive despreading code that is based on the characteristics of the received spread signal, where a given element of the spreading code corresponds to the combination of a given element of said multi-element antenna array and a given one of said discrete tones;

whereby said despreading step determines spatial and spectral components of the first spread signal in a mathematical operation that is independent of the spatial or spectral characteristics of the said components.

37. The highly bandwidth-efficient communications method of claim 36, wherein said despreading step adaptively positions the spatial direction of receive sensitivity towards a desired signal source and diminishes receive sensitivity from interfering sources.

38. The highly bandwidth-efficient communications method of claim 31, wherein the base station has a multi-element antenna array transmitting the second spread signal, and wherein said spreading step adaptively positions transmitted signal energy of said second spread signal towards a source of said first spread signal.

39. The highly bandwidth-efficient communications method of claim 31, wherein said first period and said second period comprise a time division duplex period.

40. The highly bandwidth-efficient communications method of claim 31, wherein said base station receives interference signals from interfering signal sources along with said first spread signal, said despreading step further comprising:

adaptively reducing the interference signals by adaptively adjusting said despreading codes to improve the signal quality of the received signal.

41. A highly bandwidth-efficient communications method, comprising:

a) receiving at a base station having a multi-element antenna array, in a first propagation direction, during a first time period, a first spread signal comprising a first data signal redundantly spread over a plurality of discrete tones in accordance with a first spreading code;

b) despreading the first spread signal received at the base station, using despreading codes that are determined adaptively based on at least one characteristic of the first spread signal received, in said first propagation direction, at least two of the antenna element of the said array;

c) spreading a second data signal at the base station, with second spreading codes derived from said despreading codes, said second spreading codes based on substantial channel reciprocity between said propagation direction and the reverse propagation direction, the second spreading codes redundantly spreading the second data signal over a plurality of discrete tones and over at least two of the antenna elements of the said array, to form a second spread signal that is thereby both spectrally and spatially spread; and

d) transmitting said second spread signal in said reverse propagation direction during a second time period.

42. The highly bandwidth-efficient communications method of claim 41, wherein both the first and the second spread signals have a spectral form of a discrete multitone signal transmitted on multiple antennas in said array.

43. The highly bandwidth-efficient communications method of claim 41, wherein said despreading step is a multiplication of a complex number representation of the despreading codes times a complex number representation of the first spread signal.

44. The highly bandwidth-efficient communications method of claim 41, wherein said spreading step is a multiplication of a complex number representation of the second spreading codes times a complex number representation of the second data signal.

45. The highly bandwidth-efficient communications method of claim 41, wherein said despreading step determines values of complex despreading codes which are then multiplied with a complex number representation of the received signals, resulting in an estimate of the first data signal.

46. The highly bandwidth-efficient communications method of claim 41, the despreading step further comprising:

despreading the first spread signal with a unitary, adaptive despreading code that is based on the characteristics of the received signals at the antenna elements of said array, where a given element of the spreading code corresponds to a given one of said antenna elements and a given one of said discrete tones;

whereby said despreading step treats spatial and spectral components of the first spread signal simultaneously.

47. The highly bandwidth-efficient communications method of claim 46, wherein said despreading step adaptively positions the spatial direction of receive sensitivity towards a desired signal source and diminishes receive sensitivity from interfering sources.

48. The highly bandwidth-efficient communications method of claim 41, wherein said spreading step adaptively positions transmitted signal energy of said second spread signal towards a source of said first spread signal and adaptively diminishes transmitted signal energy towards interferers.

49. The highly bandwidth-efficient communications method of claim 41, wherein said first period and said second period are parts of a time division duplex period.

50. The highly bandwidth-efficient communications method of claim 41, wherein said base station receives interference signals from interfering signal sources along with said first spread signal, said despreading step further comprising:

adaptively reducing the interference signals by adaptively adjusting said despreading codes to maximize the signal quality of the received signal.

51. A highly bandwidth-efficient communications method, comprising:

a) receiving at a base station having a multi-element antenna array, in a first propagation direction, during a first time period, a first spread signal comprising a first data signal redundantly spread over a plurality of discrete tones in accordance with a first spreading code;

b) despreading the first spread signal received at the base station, using despreading codes that are determined adaptively based on at least one characteristic of the first spread signal received, in said first propagation direction, at least two of the antenna elements of said array, where a given component of the spreading code is associated with the combination of a given one of said antenna elements and a given one of said discrete tones;

c) spreading a second data signal at the base station, with second spreading codes derived from the said despreading codes based on substantial channel reciprocity between said propagation direction and the reverse propagation direction, the second spreading codes redundantly spreading the second data signal over a plurality of discrete tones and over at least two of the antenna elements of the said array, to form a second spread signal that is spectrally and spatially spread; and

d) transmitting said second spread signal in said reverse propagation direction during a second time period.

52. The highly bandwidth-efficient communications method of claim 51, wherein both the first and the second spread signals have a spectral form of a discrete multitone signal transmitted on multiple antennas in said array.

53. The highly bandwidth-efficient communications method of claim 51, wherein said despreading step is a multiplication of a complex number representation of the despreading codes times a complex number representation of the first spread signal.

54. The highly bandwidth-efficient communications method of claim 51, wherein said spreading step is a multiplication of a complex number representation of the second spreading codes times a complex number representation of the second data signal.

55. The highly bandwidth-efficient communications method of claim 51, wherein said despreading step determines values of complex despreading codes which are then multiplied with a complex number representation of the received signals, resulting in an estimate of the first data signal.

56. The highly bandwidth-efficient communications method of claim 51, wherein said despreading step adaptively positions the spatial direction of receive sensitivity towards a desired signal source and diminishes receive sensitivity from interfering sources.

57. The highly bandwidth-efficient communications method of claim 51, wherein said spreading step adaptively positions transmitted signal energy of said second spread signal towards a source of said first spread signal and adaptively diminishes transmitted signal energy towards interferers.

58. The highly bandwidth-efficient communications method of claim 51, wherein said despreading step treats spatial and spectral components of the first spread signal simultaneously.

59. The highly bandwidth-efficient communications method of claim 51, wherein said first period and said second period are parts of a time division duplex period.

60. The highly bandwidth-efficient communications method of claim 51, wherein said base station receives interference signals from interfering signal sources along with said first spread signal, said despreading step further comprising:

adaptively reducing the interference signals by adaptively adjusting said despreading codes to maximize the signal quality of the received signal.

61. A highly bandwidth-efficient communications method, comprising:

a) receiving at a base station during a first time period a first spread signal comprising a plurality of signal clusters, each signal cluster comprising a plurality of symbols redundantly spread over a plurality of discrete tones in accordance with a first spreading code;

b) adaptively despreading the signal received at the base station by using despreading codes that are based on the characteristics of the received spread signal;

c) spreading, at the base station, using second spreading codes, a second data signal comprising a plurality of signal clusters, each signal cluster comprising a plurality of symbols, said second spreading codes derived from said despreading codes for a single symbol tone in a given cluster, the second spreading codes being applied to said plurality of symbol tones in a given cluster, said spreading step thereby spreading the second data signal over a plurality of discrete tones, to form a second spread signal; and

d) transmitting said second spread signal during a second time period.

62. The highly bandwidth-efficient communications method of claim 61, wherein both the first and the second spread signals have a spectral form of a discrete multitone signal.

63. The highly bandwidth-efficient communications method of claim 61, wherein said despreading step is a multiplication of a complex number representation of the despreading codes times a complex number representation of the first spread signal.

64. The highly bandwidth-efficient communications method of claim 61, wherein said spreading step is a multiplication of a complex number representation of the second spreading codes times a complex number representation of the second data signal.

65. The highly bandwidth-efficient communications method of claim 61, wherein said despreading step determines values of complex despreading codes which are then multiplied with a complex number representation of the received signals, resulting in an estimate of the first data signal.

66. The highly bandwidth-efficient communications method of claim 61, wherein the base station has a multi-element antenna array receiving the first spread signal, the despreading step further comprising:

despreading the first spread signal with a unitary, adaptive despreading code that is based on the characteristics of the received spread signal, where a given element of the spreading code corresponds to a given one of said multi-element antennas and a given one of said discrete tones;

whereby said despreading step treats spatial and spectral components of the first spread signal simultaneously.

67. The highly bandwidth-efficient communications method of claim 66, wherein said despreading step adaptively positions the spatial direction of receive sensitivity towards a desired signal source and diminishes receive sensitivity from interfering sources.

68. The highly bandwidth-efficient communications method of claim 61, wherein the base station has a multi-element antenna array transmitting the second spread signal, and wherein said spreading step adaptively positions transmitted signal energy of said second spread signal towards a source of said first spread signal and adaptively diminishes transmitted signal energy towards interferers.

69. The highly bandwidth-efficient communications method of claim 61, wherein said first period and said second period are parts of a time division duplex period.

70. The highly bandwidth-efficient communications method of claim 61, wherein said base station receives interference signals from interfering signal sources along with said first spread signal, said despreading step further comprising:

adaptively reducing the interference signals by adaptively adjusting said despreading codes to maximize the signal quality of the received signal.

71. A highly bandwidth-efficient communications method, comprising:

a) receiving at a base station having a multi-element antenna array, during an initialization period, a spread pilot signal comprising a known data signal spread over a plurality of discrete tones;

b) correlating said known data signal from said pilot spread signal with a reference known data signal and forming a unitary, adaptive despreading code that is based on the characteristics of the received signals at the antenna elements of said array, where a given element of the spreading code corresponds to a given one of said antenna elements and a given one of said discrete tones;

c) receiving at the base station during a first time period following said initialization period, a first spread signal comprising a first data signal spread over a plurality of discrete tones in accordance with a first spreading code assigned to the user for the first time period;

d) adaptively despreading the first spread signal with a derived despreading code that is based on said unitary, adaptive despreading code and based on the characteristics of the first spread signal and the antenna elements of said array;

e) spreading a second data signal at the base station with a second spreading code derived from said derived despreading code, that distributes the second data signal over a plurality of discrete tones and antenna elements of said array, forming a second spread signal that is spectrally and spatially spread; and

f) transmitting said second spread signal during a second time period following said first time period.

72. The highly bandwidth-efficient communications method of claim 71, wherein both the first and the second spread signals have a spectral form of a discrete multitone signal transmitted on multiple antennas in said array.

73. The highly bandwidth-efficient communications method of claim 71, wherein said despreading step is a multiplication of a complex number representation of the despreading codes times a complex number representation of the first spread signal.

74. The highly bandwidth-efficient communications method of claim 71, wherein said spreading step is a multiplication of a complex number representation of the second spreading codes times a complex number representation of the second data signal.

75. The highly bandwidth-efficient communications method of claim 71, wherein said despreading step determines values of complex despreading codes which are then multiplied with

a complex number representation of the received signals, resulting in an estimate of the first data signal.

76. The highly bandwidth-efficient communications method of claim 71, wherein said despreading step adaptively positions the spatial direction of receive sensitivity towards a desired signal source and diminishes receive sensitivity from interfering sources.

77. The highly bandwidth-efficient communications method of claim 71, wherein said spreading step adaptively positions transmitted signal energy of said second spread signal towards a source of said first spread signal and adaptively diminishes transmitted signal energy towards interferers.

78. The highly bandwidth-efficient communications method of claim 71, wherein said despreading step treats spatial and spectral components of the first spread signal simultaneously.

79. The highly bandwidth-efficient communications method of claim 71, wherein said first period and said second period are parts of a time division duplex period.

80. The highly bandwidth-efficient communications method of claim 71, wherein said base station receives interference signals from interfering signal sources along with said first spread signal, said despreading step further comprising:

adaptively reducing the interference signals by adaptively adjusting said despreading codes to maximize the signal quality of the received signal.

81. A highly bandwidth-efficient communications method, comprising:

a) receiving at a base station having a multi-element antenna array, during a first time period a first spread signal comprising a first data signal spread over a plurality of discrete tones in accordance with a first spreading code assigned to the user for the first time period;

b) adaptively despreading the first spread signal with a unitary, adaptive despreading code that is based on the characteristics of the received signals at the antenna elements of said array, where a given element of the spreading code corresponds to a given one of said antenna elements and a given one of said discrete tones;

wherein the despreading code is given by the components of a weight vector W where

$$W = (R^{-1}_{xx})r_{xy}$$

where r_{xy} is an estimate of the cross correlation vector of the received signal and an estimate of the data contained in the received signal, and R^{-1}_{xx} is an estimate of the inverted autocorrelation matrix of the received signal;

c) spreading a second data signal at the base station with a second spreading code derived from said despreading code, that distributes the second data signal over a plurality of discrete tones and antenna elements of said array, forming a second spread signal that is spectrally and spatially spread; and

d) transmitting said second spread signal during a second time period.

82. The highly bandwidth-efficient communications method of claim 81, wherein both the first and the second spread signals have a spectral form of a discrete multitone signal transmitted on multiple antennas in said array.

83. The highly bandwidth-efficient communications method of claim 81, wherein said despreading step is a multiplication of a complex number representation of the despreading codes times a complex number representation of the first spread signal.

84. The highly bandwidth-efficient communications method of claim 81, wherein said spreading step is a multiplication of a complex number representation of the second spreading codes times a complex number representation of the second data signal.

85. The highly bandwidth-efficient communications method of claim 81, wherein said despreading step determines values of complex despreading codes which are then multiplied with a complex number representation of the received signals, resulting in an estimate of the first data signal.

86. The highly bandwidth-efficient communications method of claim 81, wherein said despreading step adaptively positions the spatial direction of receive sensitivity towards a desired signal source and diminishes receive sensitivity from interfering sources.

87. The highly bandwidth-efficient communications method of claim 81, wherein said spreading step adaptively positions transmitted signal energy of said second spread signal towards a source of said first spread signal and adaptively diminishes transmitted signal energy towards interferers.

88. The highly bandwidth-efficient communications method of claim 81, wherein said despreading step treats spatial and spectral components of the first spread signal simultaneously.

89. The highly bandwidth-efficient communications method of claim 81, wherein said first period and said second period are parts of a time division duplex period.

90. The highly bandwidth-efficient communications method of claim 81, wherein said base station receives interference signals from interfering signal sources along with said first spread signal, said despreading step further comprising:

adaptively reducing the interference signals by adaptively adjusting said despreading codes to maximize the signal quality of the received signal.

91. A highly bandwidth-efficient communications method, comprising:

a) receiving at a base station having a multi-element antenna array, during a first time period a first spread signal comprising a first data signal spread over a plurality of discrete tones in accordance with a first spreading code assigned to the user for the first time period;

b) adaptively despreading the first spread signal with a unitary, adaptive despreading code that is based on the characteristics of the received signals at the antenna elements of said array;

c) forming a given traffic channel from a second data signal for transmission during a second time period at the base station with a second spreading code derived from said despreading code, comprising the steps of:

d) encrypting the second data signal producing an encrypted signal;

e) converting the encrypted signal into a vector signal;

f) trellis encoding the vector signal to form a constellation vector signal;

g) processing the adaptive despreading code to produce the second spreading code as a forward spatial and spectral spreading vector $g^{H}_{fwd}(p)$;

h) multiplying the constellation vector signal by the second spreading code to yield a matrix R(p) for the given traffic channel;

i) combining matrices R(p') of other traffic channels with the matrix R(p) of the given traffic channel to produce a combined traffic channel matrix S_{fwd} partitioned into a plurality of i submatrices (A_0 to A_i) corresponding to a plurality of i antenna elements over which the respective submatricies will be transmitted;

j) converting each of the plurality of submatricies to discrete Fourier transfer (DFT) frequency bins;

k) converting the plurality of frequency bins into a plurality of discrete frequency tones; and

l) transmitting during the second time period the plurality of discrete frequency tones over the antenna elements of said array.

92. The highly bandwidth-efficient communications method of claim 91, wherein a symbol from a link control channel is included in the vector signal.

93. The highly bandwidth-efficient communications method of claim 91, wherein a link maintenance pilot signal is included in the constellation vector signal.

94. The highly bandwidth-efficient communications method of claim 91, which further comprises the steps of:

a) multiplying the constellation vector signal d_{fwd} by a forward smearing matrix $C_{fwd\text{-}smear}$ to yield a smeared vector signal b;

b) multiplying the smeared vector signal b by a gain preemphasis vector ($_{fwd}$(p) to yield a preemphasized vector c, where p denotes the given traffic channel index and is an integer in the range [0, M_{base}] where M_{base} is a maximum number of traffic channels that can simultaneously be carried over one traffic partition; and

c) multiplying the preemphasized vector c by the second spreading code to yield said matrix R(p) for the given traffic channel.

95. The highly bandwidth-efficient communications method of claim 91, wherein said traffic channel has a high capacity mode and said trellis encoding step is performed as a 16 QAM or 16 PSK rate 3/4 trellis encoding.

96. The highly bandwidth-efficient communications method of claim 91, wherein said traffic channel has a medium capacity mode and said trellis encoding step is performed as a 8 QAM or 8 PSK rate 2/3 trellis encoding.

97. The highly bandwidth-efficient communications method of claim 91, wherein said traffic channel has a low capacity mode and said trellis encoding step is performed as a QPSK rate 1/2 trellis encoding.

98. The highly bandwidth-efficient communications method of claim 91, wherein said despreading step adaptively positions the spatial direction of receive sensitivity towards a desired signal source and diminishes receive sensitivity from interfering sources.

99. The highly bandwidth-efficient communications method of claim 91, wherein said spreading step adaptively positions transmitted signal energy of said second spread signal towards a source of said first spread signal and adaptively diminishes transmitted signal energy towards interferers.

100. The highly bandwidth-efficient communications method of claim 91, wherein said first period and said second period are parts of a time division duplex period.

101. A highly bandwidth-efficient communications method, comprising:

a) receiving at a base station having a multi-element antenna array, during a first time period a received spread signal comprising a first data signal spread over a first and second discrete tones in accordance with remote unit spreading codes assigned to a remote unit for the first time period;

b) spatially despreading the signal received at the base station by using first despreading codes that are based on the characteristics of the received signals for the first discrete tone at said multi-element antenna array, obtaining a first despread signal;

c) spatially despreading the signal received at the base station by using second despreading codes that are based on the characteristics of the received signals for the second discrete tone at said multi-element antenna array, obtaining a second despread signal; and

d) combining said first and second despread signals to recover said first data signal.

102. The highly bandwidth-efficient communications method of claim 101, wherein said combining of said first and second despread signals to recover said first data signal is by equal gain combining.

103. The highly bandwidth-efficient communications method of claim 101, wherein said combining of said first and second despread signals to recover said first data signal is by maximal ratio combining.

104. The highly bandwidth-efficient communications method of claim 101, which further comprises:

a) spatially spreading a second data signal at the base station modulated with said first tone, with first spreading codes derived from said first despreading codes forming a first spread signal;

b) spatially spreading the second data signal at the base station modulated with said second tone, with second spreading codes derived from said second despreading codes forming a second spread signal; and

c) transmitting during a second time period said first and second spread signals from said multi-element antenna array, forming a transmitted spread signal that is spectrally and spatially spread.

105. The highly bandwidth-efficient communications method of claim 101, wherein said spatially despreading steps determine values of complex despreading codes which are then multiplied with a complex number representation of the received signals, resulting in estimates of the first data signal.

106. The highly bandwidth-efficient communications method of claim 101, wherein said despreading steps adaptively position spatial directions of receive sensitivity towards a desired signal source and diminishes receive sensitivity from interfering sources.

107. The highly bandwidth-efficient communications method of claim 101, wherein said spreading steps adaptively position transmitted signal energy of said transmitted spread signal towards a source of said received spread signal and adaptively diminishes transmitted signal energy towards interferers.

108. The highly bandwidth-efficient communications method of claim 101, wherein said first period and said second period are parts of a time division duplex period.

109. A highly bandwidth-efficient communications method, comprising:

a) receiving at a base station during a first time period a first spread signal comprising a traffic data signal spread over a first plurality of discrete tones and a common access channel signal spread over a second plurality of discrete tones in accordance with a first spreading code assigned to a first user for the first time period;

b) receiving at the base station during the first time period a second spread signal comprising a common access channel data signal spread over a second plurality of discrete tones in accordance with a second spreading code assigned to a second user for the first time period;

c) adaptively despreading the first spread signal received at the base station by using first despreading codes that are based on the characteristics of the received first spread signal to recover the traffic data signal;

d) adaptively despreading the second spread signal received at the base station by using second despreading codes that are based on the characteristics of the received second spread signal to recover the common access channel data signal;

e) spreading a second traffic data signal at the base station with third spreading codes derived from said first despreading codes, that distributes the second traffic data signal over a plurality of discrete tones, forming a third spread signal; and

f) transmitting said third spread signal during a second time period.

110. The highly bandwidth-efficient communications method of claim 109, which further comprises:

a) receiving at the base station during a third time period a fourth spread signal comprising a second common access channel data signal spread over said second plurality of discrete tones in accordance with a fourth spreading code assigned to a third user for the third time period; and

b) adaptively despreading the fourth spread signal received at the base station by using third despreading codes that are based on the characteristics of the received fourth spread signal to recover the second common access channel data signal.

111. A method of analyzing a plurality of received signals, each received signal originating in a transmitted signal, transmitted by a separate transmitter spatially separated from the other transmitters, and each transmitted signal having a spectral and temporal distribution, comprising:

a) receiving the said plurality of received signals on a plurality of spatially separated antennas;

b) characterizing the plurality of received signals by 1)the receiving antenna, 2)the spectral distribution of the received signal, and 3)the temporal distribution of the received signal;

c) assigning despread weights to each characterization of the plurality of received signals;

d) determining values of the said despread weights, in a manner that is independent of the particular characterization, said despread weights, when combined with the received signals, resulting in an approximation of the transmitted signals.

e) transmitting signals to the approximate location of the said transmitter, the said signals weighted by spreading weights that are obtained from the said despread weights associated with the said transmitter.

112. A method of processing signals representative of information comprising:

a) receiving signals , representative of information, at a multi-element antenna array of a receiving station;

1. said signals having been transmitted by at least two different spatially separated sources, each of which sources having transmitted signals representative of different information;

2. the mathematical representation of the spectral characteristics of the said signals capable of being put in a mathematical form that is substantially the same as the mathematical representation of the spatial characteristics of signals received by a multi-element antenna array;

b) processing the received signals in a manner that is substantially independent of the distinction between the spectral and spatial characteristics of the signals, to obtain adaptive spectral and spatial despreading weights that enhance the signal to noise and interference ratio of the said signals, ; and

c) identifying the information associated with the signals transmitted by each of the said at least two different spatially separated sources.

113. A highly bandwidth-efficient communications system, comprising:

a base station receiving from a remote station during a first time period, a first spread signal comprising a first data signal redundantly spread over a plurality of discrete tones in accordance with a first spreading code;

a signal despreader at the base station despreading the first spread signal using despreading codes that are adaptively based on at least one characteristic of the received first spread signal;

a signal spreader at the base station spreading a second data signal using second spreading codes derived from the said despreading codes, said second spreading codes redundantly spreading the second data signal over a plurality of discrete tones, to form a second spread signal; and

said base station transmitting said second spread signal during a second time period to the remote station.

114. The highly bandwidth-efficient communications system of claim 113, wherein both the first and the second spread signals have the spectral form of a discrete multitone signal.

115. The highly bandwidth-efficient communications system of claim 113, wherein said signal despreader multiplies a complex number representation of the despreading codes times a complex number representation of the first spread signal.

116. The highly bandwidth-efficient communications system of claim 113, wherein said signal spreader multiplies a complex number representation of the second spreading codes times a complex number representation of the second data signal.

117. The highly bandwidth-efficient communications system of claim 113, wherein said signal despreader determines complex despreading code values which are then multiplied with a complex number representation of the received signals, resulting in an estimate of the first data signal.

118. The highly bandwidth-efficient communications system of claim 113, wherein the base station has a multi-element antenna array receiving the first spread signal, and the signal despreader further comprises:

means for despreading the first spread signal with an adaptive despreading code that is based on the characteristics of the received spread signal, where a given element of the spreading code corresponds to the combination of a given one of said multi-element antennas and a given one of said discrete tones;

whereby said signal despreader determines spatial and spectral components of the first spread signal in the same mathematical operation.

119. The highly bandwidth-efficient communications system of claim 118, wherein said signal despreader adaptively positions the spatial direction of receive sensitivity towards a desired signal source and diminishes receive sensitivity from interfering sources.

120. The highly bandwidth-efficient communications system of claim 113, wherein the base station has a multi-element antenna array transmitting the second spread signal, and wherein said signal spreader adaptively positions transmitted signal energy of said second spread signal towards a source of said first spread signal and adaptively diminishes transmitted signal energy towards interferers.

121. The highly bandwidth-efficient communications system of claim 113, wherein said first period and said second period comprise a time division duplex period.

122. The highly bandwidth-efficient communications system of claim 113, wherein said base station receives interference signals from interfering signal sources along with said first spread signal, said signal despreader further comprises:

means for adaptively reducing the interference signals by adaptively adjusting said despreading codes to improve a signal quality characteristic of the received signal.

123. A highly bandwidth-efficient communications system, comprising:

a remote station transmitting during a first time period, a first spread signal comprising a first data signal redundantly spread over a plurality of discrete tones in accordance with a first spreading code;

a base station receiving from the remote station during the first time period, the first spread signal;

a signal despreader at the base station despreading the first spread signal using despreading codes that are adaptively based on at least one characteristic of the received first spread signal;

a signal spreader at the base station spreading a second data signal using second spreading codes derived from the said despreading codes, said second spreading codes redundantly spreading the second data signal over a plurality of discrete tones, to form a second spread signal; and

said base station transmitting said second spread signal during a second time period to said remote station.

124. The highly bandwidth-efficient communications system of claim 123, wherein both the first and the second spread signals have the spectral form of a discrete multitone signal.

125. A highly bandwidth-efficient communications method, comprising:

a) receiving at a remote station, during a first time period, a first spread signal comprising a first data signal redundantly spread over a plurality of discrete tones in accordance with a first spreading code;

b) despreading the first spread signal received at the remote station, using despreading codes that are determined adaptively based on at least one characteristic of the received first spread signal;

c) spreading a second data signal at the remote station, using second spreading codes derived from the said despreading codes, said second spreading codes redundantly spreading the second data signal over a plurality of discrete tones, to form a second spread signal; and

d) transmitting said second spread signal during a second time period.

126. The highly bandwidth-efficient communications method of claim 125, wherein both the first and the second spread signals have the spectral form of a discrete multitone signal.

127. The highly bandwidth-efficient communications method of claim 125, wherein said despreading step comprises multiplication of a complex number representation of the despreading codes times a complex number representation of the first spread signal.

128. The highly bandwidth-efficient communications method of claim 125, wherein said spreading step comprises multiplication of a complex number representation of the second spreading codes times a complex number representation of the second data signal.

129. The highly bandwidth-efficient communications method of claim 125, wherein said despreading step comprises determination of complex despreading code values which are then multiplied with a complex number representation of the received signals, resulting in an estimate of the first data signal.

130. The highly bandwidth-efficient communications method of claim 125, wherein the remote station has a multi-element antenna array receiving the first spread signal, and the despreading step further comprising:

> despreading the first spread signal with an adaptive despreading code that is based on the characteristics of the received spread signal, where a given element of the spreading code corresponds to the combination of a given one of said multi-element antennas and a given one of said discrete tones;

whereby said despreading step determines spatial and spectral components of the first spread signal in the same mathematical operation.

131. The highly bandwidth-efficient communications method of claim 130, wherein said despreading step adaptively positions the spatial direction of receive sensitivity towards a desired signal source and diminishes receive sensitivity from interfering sources.

132. The highly bandwidth-efficient communications method of claim 125, wherein the remote station has a multi-element antenna array transmitting the second spread signal, and wherein said spreading step adaptively positions transmitted signal energy of said second spread signal towards a source of said first spread signal and adaptively diminishes transmitted signal energy towards interferers.

133. The highly bandwidth-efficient communications method of claim 125, wherein said first period and said second period comprise a time division duplex period.

134. The highly bandwidth-efficient communications method of claim 125, wherein said remote station receives interference signals from interfering signal sources along with said first spread signal, said despreading step further comprising:

adaptively reducing the interference signals by adaptively adjusting said despreading codes to improve a signal quality characteristic of the received signal.

135. A highly bandwidth-efficient communications method, comprising:

a) receiving at a base station, during a first time period, a first spread signal comprising a first data signal redundantly spread over a plurality of discrete tones in accordance with a first spreading code;
b) said plurality of descrete tones being divided into a first subplurality occupying a first frequency sub-band and a second subplurality occupying a second sub-band, said first sub-band being separated from said second sub-band by a frequency band gap;
c) despreading the first spread signal received at the base station, using despreading codes that are determined adaptively based on at least one characteristic of the received first spread signal;
d) spreading a second data signal at the base station, using second spreading codes derived from the said despreading codes, said second spreading codes redundantly spreading the second data signal over a plurality of discrete tones, to form a second spread signal; and
e) transmitting said second spread signal during a second time period.

136. The highly bandwidth-efficient communications method of claim 135, wherein both the first and the second spread signals have the spectral form of a discrete multitone signal.

137. The highly bandwidth-efficient communications method of claim 135, wherein the base station has a multi-element antenna array receiving the first spread signal, and the despreading step further comprising:

despreading the first spread signal with an adaptive despreading code that is based on the characteristics of the received spread signal, where a given element of the spreading code corresponds to the combination of a given one of said multi-element antennas and a given one of said discrete tones;

whereby said despreading step determines spatial and spectral components of the first spread signal in the same mathematical operation.

138. The highly bandwidth-efficient communications method of claim 137, wherein said despreading step adaptively positions the spatial direction of receive sensitivity towards a desired signal source and diminishes receive sensitivity from interfering sources.

139. The highly bandwidth-efficient communications method of claim 135, wherein the base station has a multi-element antenna array transmitting the second spread signal, and wherein said spreading step adaptively positions transmitted signal energy of said second spread signal towards a source of said first spread signal and adaptively diminishes transmitted signal energy towards interferers.

140. The highly bandwidth-efficient communications method of claim 135, wherein said first period and said second period comprise a time division duplex period.

141. The highly bandwidth-efficient communications method of claim 135, wherein said base station receives interference signals from interfering signal sources along with said first spread signal, said despreading step further comprising:

adaptively reducing the interference signals by adaptively adjusting said despreading codes to improve a signal quality characteristic of the received signal.

142. The highly bandwidth-efficient communications method of claim 135, wherein said plurality of descrete tones is divided into a first subplurality occupying a first frequency sub-band, a second subplurality occupying a second sub-band, and a third subplurality occupying a third sub-band, said first sub-band being separated from said second sub-band by a frequency band gap and said second sub-band being separated from said third sub-band by a frequency band gap.

143. A highly bandwidth-efficient communications method, comprising:

a) receiving at a remote station, during a first time period, a first spread signal comprising a first data signal redundantly spread over a plurality of discrete tones in accordance with a first spreading code;

b) said plurality of descrete tones being divided into a first subplurality occupying a first frequency sub-band and a second subplurality occupying a second sub-band, said first sub-band being separated from said second sub-band by a frequency band gap;

c) despreading the first spread signal received at the remote station, using despreading codes that are determined adaptively based on at least one characteristic of the received first spread signal;

d) spreading a second data signal at the remote station, using second spreading codes derived from the said despreading codes, said second spreading codes redundantly spreading the second data signal over a plurality of discrete tones, to form a second spread signal; and

e) transmitting said second spread signal during a second time period.

144. The highly bandwidth-efficient communications method of claim 143, wherein both the first and the second spread signals have the spectral form of a discrete multitone signal.

145. The highly bandwidth-efficient communications method of claim 143, wherein said plurality of descrete tones is divided into a first subplurality occupying a first frequency sub-band, a second subplurality occupying a second sub-band, and a third subplurality occupying a third sub-band, said first sub-band being separated from said second sub-band by a frequency band gap and said second sub-band being separated from said third sub-band by a frequency band gap.

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146. A highly bandwidth-efficient communications method, comprising the steps of:

receiving at a base station a spread signal comprising an incoming data traffic signal spread over a plurality of discrete traffic frequencies and an incoming connection request signal from a remote station, spread over a plurality of common access channel frequencies;

adaptively despreading the signals received at the base station by using despreading weights;

accessing a database at the base station and simultaneously (1) transmitting the connection request and a subscriber profile to a network switch for call set up, and (2) initiating a traffic channel between the base station and the remote station; and

signalling the network switch to disassemble the connection when the base station indicates a traffic channel cannot be established with the remote station.

147. The highly bandwidth-efficient communications method of claim 146, wherein said base station and said remote station are part of a wireless discrete multitone spread spectrum communications system.

148. The highly bandwidth-efficient communications method of claim 146, wherein said incoming connection request signal includes a connection request, a remote station identification, and a subscriber line number to the base station.

149. The highly bandwidth-efficient communications method of claim 146, wherein said step of accessing a database includes the step of identifying a particular subscriber and related profile for use by the network switch.

150. The highly bandwidth-efficient communications method of claim 146, wherein said database includes subscriber spreading weights and despreading weights used in processing messages between the remote station and the base station.

151. A highly bandwidth-efficient communications method, comprising the steps of:

receiving at a base station a first spread signal comprising an incoming data traffic signal having a data portion spread over a plurality of discrete traffic frequencies, from a remote station;

receiving at said base station a second spread signal comprising an incoming connection request signal from the remote station, spread over a plurality of common access channel frequencies;

adaptively despreading said second spread signal received at the base station by using despreading weights, recovering said connection request;

accessing a database at the base station and simultaneously (1) transmitting the connection request and a subscriber profile to a network switch for call set up, and (2) initiating a traffic channel between the base station and the remote station; and

signalling the network switch to disassemble the connection when the base station indicates a traffic channel cannot be established with the remote station.

152. The highly bandwidth-efficient communications method of claim 151, wherein said base station and said remote station are part of a wireless discrete multitone spread spectrum communications system.

153. The highly bandwidth-efficient communications method of claim 151, wherein said incoming connection request signal includes a connection request, a remote station identification, and a subscriber line number to the base station.

154. The highly bandwidth-efficient communications method of claim 151, wherein said step of accessing a database includes the step of identifying a particular subscriber and related profile for use by the network switch.

155. The highly bandwidth-efficient communications method of claim 151, wherein said database includes subscriber spreading weights and despreading weights used in processing messages between the remote station and the base station.

156. A wireless communication system with improved access to a communication network, comprising:

at least one remote station coupled to a wireless link and serving multiple subscribers;

a base station coupled to the wireless link and communicating with at least one remote station using a Common Access Channel (CAC) and a Common Link Channel (CLC);

a network switch coupled to the base station and to the communication network;

means for originating a call at the remote station and transmitting a connection request, remote station identification, and subscriber line number to the base station over the common access channel;

base station means responsive to the call for accessing a database and simultaneously (1) transmitting the connection request and a subscriber profile to the network switch for call set up, and (2) initiating a traffic channel between the base station and a remote station; and

an error processor included in the base station for signalling the network switch to the disassemble the connection when the base station indicates a traffic channel cannot be established.

157. A highly bandwidth-efficient communications method, comprising the steps of:

receiving at a base station a spread signal comprising an incoming data traffic signal spread over a plurality of discrete traffic frequencies and an incoming message segment signal spread over a plurality of link control frequencies;

adaptively despreading the signals received at the base station by using despreading weights;

detecting a priority interrupt flag value in said message segment signal;

resetting a message segment buffer in said base station and storing a message segment therein, if said priority interrupt flag has a first value;

concatenating said message segment with a previously received message segment, if said priority interrupt flag has a second value.

158. The highly bandwidth-efficient communications method of claim 157, wherein said base station is part of a wireless discrete multitone spread spectrum communications system.

159. The highly bandwidth-efficient communications method of claim 157, wherein said message segment is a system management message segment.

160. The highly bandwidth-efficient communications method of claim 157, wherein said first value of said priority interrupt flag corresponds to a time critical message segment.

161. The highly bandwidth-efficient communications method of claim 157, wherein said second value of said priority interrupt flag corresponds to a message segment that is not a first segment.

162. A highly bandwidth-efficient communications method, comprising the steps of:

receiving at a base station a first spread signal comprising an incoming data traffic signal having a data portion spread over a plurality of discrete traffic frequencies;

receiving at said base station a second spread signal comprising an incoming message segment signal having a message segment portion and a priority interrupt flag portion spread over a plurality of link control frequencies;

adaptively despreading said first spread signal received at the base station by using despreading weights, recovering said data portion;

adaptively despreading said second spread signal received at the base station by using despreading weights, recovering said message segment portion and said priority interrupt flag portion;

resetting a message segment buffer in said base station and storing said message segment portion therein, if said priority interrupt flag has a first value;

concatenating said message segment portion with a previously received message segment, if said priority interrupt flag has a second value.

163. The highly bandwidth-efficient communications method of claim 162, wherein said base station is part of a wireless discrete multitone spread spectrum communications system.

164. The highly bandwidth-efficient communications method of claim 162, wherein said message segment is a system management message segment.

165. The highly bandwidth-efficient communications method of claim 162, wherein said first value of said priority interrupt flag corresponds to a time critical message segment.

166. The highly bandwidth-efficient communications method of claim 162, wherein said second value of said priority interrupt flag corresponds to a message segment that is not a first segment.

167. A highly bandwidth-efficient communications method, comprising the steps of:

transmitting from a base station a transmitted spread signal comprising an outgoing data traffic signal spread over a plurality of discrete traffic frequencies and an outgoing message segment signal spread over a plurality of link control frequencies;

said outgoing message segment signal being part of a low priority message having a second outgoing message segment signal to be transmitted ;

receiving at said base station a spread signal comprising an incoming data traffic signal spread over a plurality of discrete traffic frequencies and an incoming message segment signal spread over a plurality of link control frequencies;

adaptively despreading the signals received at the base station by using despreading weights;

detecting a priority interrupt flag value in said message segment signal;

interrupting transmission of said second outgoing message segment signal, resetting a message segment buffer in said base station, and storing said incoming message segment signal therein, if said priority interrupt flag has a first value;

concatenating said incoming message segment signal with a previously received message segment, if said priority interrupt flag has a second value.

of a wireless discrete multitone spread spectrum communications system.

168. The highly bandwidth-efficient communications method of claim 11, wherein said message segment signals are system management message segment signals.

169. The highly bandwidth-efficient communications method of claim 11, wherein said first value of said priority interrupt flag corresponds to a time critical message segment signal.

170. The highly bandwidth-efficient communications method of claim 11, wherein said second value of said priority interrupt flag corresponds to a message segment signal that is not a first segment.

171. A highly bandwidth-efficient communications method, comprising the steps of:

transmitting from a base station a transmitted spread signal comprising an outgoing data traffic signal spread over a plurality of discrete traffic frequencies and an outgoing message segment signal spread over a plurality of link control frequencies;

said outgoing message segment signal being part of a low priority message having a second outgoing message segment signal to be transmitted ;

receiving at a base station a first spread signal comprising an incoming data traffic signal having a data portion spread over a plurality of discrete traffic frequencies;

receiving at said base station a second spread signal comprising an incoming message segment signal having a message segment portion and a priority interrupt flag portion spread over a plurality of link control frequencies;

adaptively despreading said first spread signal received at the base station by using despreading weights, recovering said data portion;

adaptively despreading said second spread signal received at the base station by using despreading weights, recovering said message segment portion and said priority interrupt flag portion;

interrupting transmission of said second outgoing message segment signal, resetting a message segment buffer in said base station and storing said message segment portion therein, if said priority interrupt flag has a first value;

concatenating said message segment portion with a previously received message segment, if said priority interrupt flag has a second value.

172. The highly bandwidth-efficient communications method of claim 162, wherein said base station is part of a wireless discrete multitone spread spectrum communications system.

173. The highly bandwidth-efficient communications method of claim 162, wherein said message segment is a system management message segment.

174. The highly bandwidth-efficient communications method of claim 162, wherein said first value of said priority interrupt flag corresponds to a time critical message segment.

175. The highly bandwidth-efficient communications method of claim 162, wherein said second value of said priority interrupt flag corresponds to a message segment that is not a first segment.

176. A highly bandwidth-efficient communications method, comprising the steps of:

receiving at a station a spread signal comprising an incoming data traffic signal spread over a plurality of discrete traffic frequencies and an incoming message segment signal spread over a plurality of link control frequencies;

adaptively despreading the signals received at the station by using despreading weights;

detecting a priority interrupt flag value in said message segment signal;

resetting a message segment buffer in said station and storing a message segment therein, if said priority interrupt flag has a first value;

concatenating said message segment with a previously received message segment, if said priority interrupt flag has a second value.

177. The highly bandwidth-efficient communications method of claim 176, wherein said station is part of a wireless discrete multitone spread spectrum communications system.

178. The highly bandwidth-efficient communications method of claim 176, wherein said message segment is a system management message segment.

179. The highly bandwidth-efficient communications method of claim 176, wherein said first value of said priority interrupt flag corresponds to a time critical message segment.

180. The highly bandwidth-efficient communications method of claim 176, wherein said second value of said priority interrupt flag corresponds to a message segment that is not a first segment.

181. The highly bandwidth-efficient communications method of claim 176, wherein said station is a base station in a wireless discrete multitone spread spectrum communications system.

182. The highly bandwidth-efficient communications method of claim 176, wherein said station is a remote station in a wireless discrete multitone spread spectrum communications system.

183. A highly bandwidth-efficient communications method, comprising the steps of:

receiving at a station a first spread signal comprising an incoming data traffic signal having a data portion spread over a plurality of discrete traffic frequencies;

receiving at said station a second spread signal comprising an incoming message segment signal having a message segment portion and a priority interrupt flag portion spread over a plurality of link control frequencies;

adaptively despreading said first spread signal received at the station by using despreading weights, recovering said data portion;

adaptively despreading said second spread signal received at the station by using despreading weights, recovering said message segment portion and said priority interrupt flag portion;

resetting a message segment buffer in said station and storing said message segment portion therein, if said priority interrupt flag has a first value;

concatenating said message segment portion with a previously received message segment, if said priority interrupt flag has a second value.

184. The highly bandwidth-efficient communications method of claim 183, wherein said station is a base station in a wireless discrete multitone spread spectrum communications system.

185. The highly bandwidth-efficient communications method of claim 183, wherein said station is a remote station in a wireless discrete multitone spread spectrum communications system.

186. A highly bandwidth-efficient communications system, comprising:

means for receiving at a base station a spread signal comprising an incoming data traffic signal spread over a plurality of discrete traffic frequencies and an incoming message segment signal spread over a plurality of link control frequencies;

means for adaptively despreading the signals received at the base station by using despreading weights;

means for detecting a priority interrupt flag value in said message segment signal;

means for resetting a message segment buffer in said base station and storing a message segment therein, if said priority interrupt flag has a first value;

means for concatenating said message segment with a previously received message segment, if said priority interrupt flag has a second value.

187. The highly bandwidth-efficient communications system of claim 186, wherein said base station is part of a wireless discrete multitone spread spectrum communications system.

188. The highly bandwidth-efficient communications system of claim 186, wherein said message segment is a system management message segment.

189. The highly bandwidth-efficient communications system of claim 186, wherein said first value of said priority interrupt flag corresponds to a time critical message segment.

190. The highly bandwidth-efficient communications system of claim 186, wherein said second value of said priority interrupt flag corresponds to a message segment that is not a first segment.

191. A highly bandwidth-efficient communications system, comprising:

means for receiving at a station a first spread signal comprising an incoming data traffic signal having a data portion spread over a plurality of discrete traffic frequencies;

means for receiving at said station a second spread signal comprising an incoming message segment signal having a message segment portion and a priority interrupt flag portion spread over a plurality of link control frequencies;

means for adaptively despreading said first spread signal received at the station by using despreading weights, recovering said data portion;

means for adaptively despreading said second spread signal received at the station by using despreading weights, recovering said message segment portion and said priority interrupt flag portion;

means for resetting a message segment buffer in said station and storing said message segment portion therein, if said priority interrupt flag has a first value;

means for concatenating said message segment portion with a previously received message segment, if said priority interrupt flag has a second value.

192. The highly bandwidth-efficient communications system of claim 191, wherein said station is a base station in a wireless discrete multitone spread spectrum communications system.

193. The highly bandwidth-efficient communications system of claim 191, wherein said station is a remote station in a wireless discrete multitone spread spectrum communications system.

194. A highly bandwidth-efficient communications method, comprising the steps of:

receiving at a base station a spread signal comprising an incoming data traffic signal spread over a plurality of discrete traffic frequencies and an incoming functional quality and maintenance signal characterizing a remote station, spread over a plurality of common access channel frequencies;

adaptively despreading the signals received at the base station by using despreading weights;

storing said functional quality and maintenance signal at said base station;

analyzing functional quality data from said functional quality and maintenance signal and updating said despreading weights at the base station; and

analyzing maintenance data from said functional quality and maintenance signal and outputting a maintenance notice at the base station.

195. The highly bandwidth-efficient communications method of claim 194, wherein said base station and said remote station are part of a wireless discrete multitone spread spectrum communications system.

196. The highly bandwidth-efficient communications method of claim 194, wherein said step of analyzing functional quality data further comprises:

updating spreading weights at the base station.

197. The highly bandwidth-efficient communications method of claim 194, wherein said functional quality data includes SINR history data characterizing communications with said remote station.

198. The highly bandwidth-efficient communications method of claim 194, wherein said functional quality data includes path loss history data characterizing communications with said remote station.

199. The highly bandwidth-efficient communications method of claim 194, wherein said maintenance data includes self-test results data characterizing said remote station.

200. The highly bandwidth-efficient communications method of claim 194, wherein said maintenance data includes battery status data characterizing said remote station.

201. The highly bandwidth-efficient communications method of claim 194, which further comprises:

initiating an update in spreading and despreading weights at the base station in an effort to improve the signal and interference to noise ratio of a traffic channel, in response to said functional quality data.

202. The highly bandwidth-efficient communications method of claim 194, which further comprises:

initiating an alarm at the base station to be used for realtime control, in response to said functional quality data.

203. The highly bandwidth-efficient communications method of claim 194, which further comprises:

logging the functional quality data for compilation of a longer term report of a traffic channel quality, in response to said functional quality signal.

204. A highly bandwidth-efficient communications method, comprising the steps of:

receiving at a base station a first spread signal comprising an incoming data traffic signal having a data portion spread over a plurality of discrete traffic frequencies, from a remote station;

receiving at said base station a second spread signal comprising an incoming functional quality and maintenance signal having a functional quality data portion and maintenance data portion spread over a plurality of common access channel frequencies, from said remote station;

adaptively despreading said second spread signal received at the base station by using despreading weights, recovering said functional quality data portion and said maintenance data portion;

storing said functional quality data and maintenance data at said base station;

analyzing said functional quality data and updating said despreading weights at the base station; and

analyzing said maintenance data and outputting a maintenance notice at the base station.

205. The highly bandwidth-efficient communications method of claim 204, wherein said base station and said remote station are part of a wireless discrete multitone spread spectrum communications system.

206. The highly bandwidth-efficient communications method of claim 204, wherein said step of analyzing functional quality data further comprises:

updating spreading weights at the base station.

207. The highly bandwidth-efficient communications method of claim 204, wherein said functional quality data includes SINR history data characterizing communications with said remote station.

208. The highly bandwidth-efficient communications method of claim 204, wherein said functional quality data includes path loss history data characterizing communications with said remote station.

209. The highly bandwidth-efficient communications method of claim 204, wherein said maintenance data includes self-test results data characterizing said remote station.

210. The highly bandwidth-efficient communications method of claim 204, wherein said maintenance data includes battery status data characterizing said remote station.

211. The highly bandwidth-efficient communications method of claim 204, which further comprises:

initiating an update in spreading and despreading weights at the base station in an effort to improve the signal and interference to noise ratio of a traffic channel, in response to said functional quality data.

212. The highly bandwidth-efficient communications method of claim 204, which further comprises:

initiating an alarm at the base station to be used for realtime control, in response to said functional quality data.

213. The highly bandwidth-efficient communications method of claim 204, which further comprises:

logging the functional quality data for compilation of a longer term report of a traffic channel quality, in response to said functional quality signal.

214. A highly bandwidth-efficient communications system, comprising:

means for receiving at a base station a spread signal comprising an incoming data traffic signal spread over a plurality of discrete traffic frequencies and an incoming functional quality and maintenance signal characterizing a remote station, spread over a plurality of common access channel frequencies;

means for adaptively despreading the signals received at the base station by using despreading weights;

means for storing said functional quality and maintenance signal at said base station;

means for analyzing functional quality data from said functional quality and maintenance signal and updating said despreading weights at the base station; and

means for analyzing maintenance data from said functional quality and maintenance signal and outputting a maintenance notice at the base station.

215. The highly bandwidth-efficient communications system of claim 214, wherein said base station and said remote station are part of a wireless discrete multitone spread spectrum communications system.

216. The highly bandwidth-efficient communications system of claim 214, which further comprises:

means for analyzing functional quality data by updating spreading weights at the base station.

217. The highly bandwidth-efficient communications system of claim 214, wherein said functional quality data includes SINR history data characterizing communications with said remote station.

218. The highly bandwidth-efficient communications system of claim 214, wherein said functional quality data includes path loss history data characterizing communications with said remote station.

219. The highly bandwidth-efficient communications system of claim 214, wherein said maintenance data includes self-test results data characterizing said remote station.

220. The highly bandwidth-efficient communications system of claim 214, wherein said maintenance data includes battery status data characterizing said remote station.

221. The highly bandwidth-efficient communications system of claim 214, which further comprises:

means for initiating an update in spreading and despreading weights at the base station in an effort to improve the signal and interference to noise ratio of a traffic channel, in response to said functional quality data.

222. The highly bandwidth-efficient communications system of claim 214, which further comprises:

means for initiating an alarm at the base station to be used for realtime control, in response to said functional quality data.

223. The highly bandwidth-efficient communications system of claim 214, which further comprises:

means for logging the functional quality data for compilation of a longer term report of a traffic channel quality, in response to said functional quality signal.

224. A highly bandwidth-efficient communications system, comprising:

means for receiving at a base station a first spread signal comprising an incoming data traffic signal having a data portion spread over a plurality of discrete traffic frequencies, from a remote station;

means for receiving at said base station a second spread signal comprising an incoming functional quality and maintenance signal having a functional quality data portion and maintenance data portion spread over a plurality of common access channel frequencies, from said remote station;

means for adaptively despreading said second spread signal received at the base station by using despreading weights, recovering said functional quality data portion and said maintenance data portion;

means for storing said functional quality data and maintenance data at said base station;

means for analyzing said functional quality data and updating said despreading weights at the base station; and

means for analyzing said maintenance data and outputting a maintenance notice at the base station.

225. The highly bandwidth-efficient communications system of claim 224, wherein said base station and said remote station are part of a wireless discrete multitone spread spectrum communications system.

226. The highly bandwidth-efficient communications system of claim 224, which further comprises:

means for analyzing functional quality data by updating spreading weights at the base station.

227. The highly bandwidth-efficient communications system of claim 224, wherein said functional quality data includes SINR history data characterizing communications with said remote station.

228. The highly bandwidth-efficient communications system of claim 224, wherein said functional quality data includes path loss history data characterizing communications with said remote station.

229. The highly bandwidth-efficient communications system of claim 224, wherein said maintenance data includes self-test results data characterizing said remote station.

230. The highly bandwidth-efficient communications system of claim 224, wherein said maintenance data includes battery status data characterizing said remote station.

231. The highly bandwidth-efficient communications system of claim 224, which further comprises:

means for initiating an update in spreading and despreading weights at the base station in an effort to improve the signal and interference to noise ratio of a traffic channel, in response to said functional quality data.

232. The highly bandwidth-efficient communications system of claim 224, which further comprises:

means for initiating an alarm at the base station to be used for realtime control, in response to said functional quality data.

233. The highly bandwidth-efficient communications system of claim 224, which further comprises:

means for logging the functional quality data for compilation of a longer term report of a traffic channel quality, in response to said functional quality signal.

234. A highly bandwidth-efficient communications method to control the power level of signals transmitted by remote stations and base stations in a DMT-SS wireless network, comprising:

transmitting from the base station, forward pilot tones with a prearranged initial forward signal power level, to the remote station;

receiving at the remote station the forward pilot tones with a signal power level that is less than the prearranged initial forward signal power level, the difference being a measure of the channel loss between the base station and the remote station;

storing at the remote station the value of the channel loss it measures;

transmitting from the remote station, reverse pilot tones with a prearranged initial reverse signal power level, to the base station;

receiving at the base station the reverse pilot tones with a signal power level that is less than the prearranged initial reverse signal power level, the difference being a measure of the channel loss between the base station and the remote station;

storing at the base station the value of the channel loss it measures;

preparing at the base station despreading weights to despread DMT-SS signals it receives from the remote station;

computing at the base station spreading weights for transmission of DMT-SS signals to the remote station, the spreading weights calculated at the base station including a factor based on the measured channel loss stored at the base station, to overcome the channel loss so that forward signals transmitted to the remote station will arrive there with a desired received signal power level;

preparing at the remote station despreading weights to despread DMT-SS signals it receives from the base station;

computing at the remote station spreading weights for transmission of DMT-SS signals to the base station, the spreading weights calculated at the remote station including a factor based on the measured channel loss stored at the remote station, to overcome the channel loss so that reverse signals transmitted to the base station will arrive there with a desired received signal power level;

whereby the power level of signals transmitted by remote stations and base stations is controlled to minimize interference while insuring that signals reach their intended destination.

235. The highly bandwidth-efficient communications method to control the power level of signals transmitted by remote stations and base stations in a DMT-SS wireless network of claim 234,

wherein both the forward pilot tones and the reverse pilot tones have a spectral form of a discrete multitone signal.

236. The highly bandwidth-efficient communications method to control the power level of signals transmitted by remote stations and base stations in a DMT-SS wireless network of claim 234, wherein said computing spreading weights at the base station uses the principle of retrodirectivity.

237. The highly bandwidth-efficient communications method to control the power level of signals transmitted by remote stations and base stations in a DMT-SS wireless network of claim 234, wherein said computing spreading weights at the remote station uses the principle of retrodirectivity.

238. The highly bandwidth-efficient communications method to control the power level of signals transmitted by remote stations and base stations in a DMT-SS wireless network of claim 234, wherein the base station has a multi-element antenna array for receiving DMT-SS spread signals, receiving steps at the base station comprising:

despreading DMT-SS spread signals with a unitary, adaptive despreading code that is based on the characteristics of a received spread signal, where a given element of the despreading code corresponds to a given one of said multi-element antennas and a given one of a plurality of received, discrete tones;

whereby spatial and spectral samples of the DMT-SS spread signals are treated simultaneously.

239. The highly bandwidth-efficient communications method to control the power level of signals transmitted by remote stations and base stations in a DMT-SS wireless network of claim 234, wherein the forward pilot tones and the reverse pilot tones are transmitted during consecutive parts of a time division duplex period.

240. A highly bandwidth-efficient communications system to control the power level of signals transmitted by remote stations and base stations in a DMT-SS wireless network, comprising:

means for transmitting from the base station, forward pilot tones with a prearranged initial forward signal power level, to the remote station;

means for receiving at the remote station the forward pilot tones with a signal power level that is less than the prearranged initial forward signal power level, the difference being a measure of the channel loss between the base station and the remote station;

means for storing at the remote station the value of the channel loss it measures;

means for transmitting from the remote station, reverse pilot tones with a prearranged initial reverse signal power level, to the base station;

means for receiving at the base station the reverse pilot tones with a signal power level that is less than the prearranged initial reverse signal power level, the difference being a measure of the channel loss between the base station and the remote station;

means for storing at the base station the value of the channel loss it measures;

means for preparing at the base station despreading weights to despread DMT-SS signals it receives from the remote station;

means for computing at the base station spreading weights for transmission of DMT-SS signals to the remote station, the spreading weights calculated at the base station including a factor based on the measured channel loss stored at the base station, to overcome the channel loss so that forward signals transmitted to the remote station will arrive there with a desired received signal power level;

means for preparing at the remote station despreading weights to despread DMT-SS signals it receives from the base station;

means for computing at the remote station spreading weights for transmission of DMT-SS signals to the base station, the spreading weights calculated at the remote station including a factor based on the measured channel loss stored at the remote station, to overcome the channel loss so that reverse signals transmitted to the base station will arrive there with a desired received signal power level;

whereby the power level of signals transmitted by remote stations and base stations is controlled to minimize interference while insuring that signals reach their intended destination.

241. The highly bandwidth-efficient communications system to control the power level of signals transmitted by remote stations and base stations in a DMT-SS wireless network of claim 240, wherein both the forward pilot tones and the reverse pilot tones have a spectral form of a discrete multitone signal.

242. The highly bandwidth-efficient communications system to control the power level of signals transmitted by remote stations and base stations in a DMT-SS wireless network of claim 240, wherein said computing spreading weights at the base station uses the principle of retrodirectivity.

243. The highly bandwidth-efficient communications system to control the power level of signals transmitted by remote stations and base stations in a DMT-SS wireless network of claim 240, wherein said computing spreading weights at the remote station uses the principle of retrodirectivity.

244. The highly bandwidth-efficient communications system to control the power level of signals transmitted by remote stations and base stations in a DMT-SS wireless network of claim 240, wherein the base station has a multi-element antenna array for receiving DMT-SS spread signals, further comprising:

means for despreading DMT-SS spread signals with a unitary, adaptive despreading code that is based on the characteristics of a received spread signal, where a given element of the despreading code corresponds to a given one of said multi-element antennas and a given one of a plurality of received, discrete tones;

whereby spatial and spectral samples of the DMT-SS spread signals are treated simultaneously.

245. The highly bandwidth-efficient communications system to control the power level of signals transmitted by remote stations and base stations in a DMT-SS wireless network of claim 240, wherein the forward pilot tones and the reverse pilot tones are transmitted during consecutive parts of a time division duplex period.

246. A highly bandwidth-efficient communications method to optimize a multiple cell network for inter-cell interference, comprising:

receiving at a first base station located in a first cell, a first spread signal comprising a first data signal spread over a plurality of discrete tones received over a first path from a first remote station located in said first cell, said first signal further comprising an interfering signal spread over said plurality of discrete tones received over an interference path from a second remote station located in a second cell;

adaptively despreading the signal received at the first base station by using first despreading codes that are based on the characteristics of the received spread signal over said first path and over said interference path;

spreading a second data signal at the base station with first spreading codes derived from said despreading codes based on a retrodirectivity of said first path and of said interference path, the first spreading codes distributing the second data signal over a plurality of discrete tones, forming a second spread signal that is selectively diminished in said interfering path to said second remote station;

transmitting said second spread signal from the first base station over said first path to said first remote station and transmitting the second signal selectively diminished over said interference path to said second remote station;

receiving at said second remote station said selectively diminished second spread signal;

adaptively despreading the selectively diminished second signal received at the second remote station by using second despreading codes that are based on the characteristics of the received second signal over said interference path;

spreading a third data signal at the second remote station with second spreading codes derived from said second despreading codes based on a retrodirectivity of said interference path, the second spreading codes distributing the third data signal over a plurality of discrete tones, forming a third spread signal that is selectively diminished in said interfering path to said first base station;

and

transmitting said selectively diminished third spread signal from the second remote station over said interference path to said first base station.

247. The highly bandwidth-efficient communications method to optimize a multiple cell network for inter-cell interference of claim 246, wherein both the first and the second spread signals have a spectral form of a discrete multitone signal.

248. The highly bandwidth-efficient communications method to optimize a multiple cell network for inter-cell interference of claim 246, wherein said first said despreading step is a multiplication of a complex number representation of the despreading codes times a complex number representation of the first spread signal.

249. The highly bandwidth-efficient communications method to optimize a multiple cell network for inter-cell interference of claim 246, wherein said first said spreading step is a multiplication of a complex number representation of the second spreading codes times a complex number representation of the second data signal.

250. The highly bandwidth-efficient communications method to optimize a multiple cell network for inter-cell interference of claim 246, wherein said first said despreading step determines values of complex despreading codes which are then multiplied with a complex number representation of the received signals, resulting in an estimate of the first data signal.

251. The highly bandwidth-efficient communications method to optimize a multiple cell network for inter-cell interference of claim 246, wherein the first base station has a multi-element antenna array receiving the first spread signal, the despreading step further comprising:

despreading the first spread signal with a unitary, adaptive despreading code that is based on the characteristics of the received spread signal, where a given element of the spreading code corresponds to a given one of said multi-element antennas and a given one of said discrete tones;

whereby said despreading step treats spatial and spectral samples of the first spread signal simultaneously.

252. The highly bandwidth-efficient communications method to optimize a multiple cell network for inter-cell interference of claim 246, wherein said first said despreading step adaptively positions the spatial direction of receive sensitivity towards a desired signal source and diminishes receive sensitivity from interfering sources.

253. The highly bandwidth-efficient communications method to optimize a multiple cell network for inter-cell interference of claim 246, wherein the first base station has a multi-element antenna array transmitting the second spread signal, and wherein said first said

spreading step adaptively positions transmitted signal energy of said second spread signal towards a source of said first spread signal and adaptively diminishes transmitted signal energy towards interferers.

254. The highly bandwidth-efficient communications method to optimize a multiple cell network for inter-cell interference of claim 246, wherein said first and second signals are transmitted during consecutive parts of a time division duplex period.

255. The highly bandwidth-efficient communications method to optimize a multiple cell network for inter-cell interference of claim 246, wherein said first base station receives interference signals from interfering signal sources along with said first spread signal, said first said despreading step further comprising:

adaptively reducing the interference signals by adaptively adjusting said first despreading codes to maximize the signal quality of the received signal.

256. A highly bandwidth-efficient communications system to optimize a multiple cell network for inter-cell interference, comprising:

means for receiving at a first base station located in a first cell, a first spread signal comprising a first data signal spread over a plurality of discrete tones received over a first path from a first remote station located in said first cell, said first signal further comprising an interfering signal spread over said plurality of discrete tones received over an interference path from a second remote station located in a second cell;

means for adaptively despreading the signal received at the first base station by using first despreading codes that are based on the characteristics of the received spread signal over said first path and over said interference path;

means for spreading a second data signal at the base station with first spreading codes derived from said despreading codes based on a retrodirectivity of said first path and of said interference path, the first spreading codes distributing the second data signal over a plurality of discrete tones, forming a second spread signal that is selectively diminished in said interfering path to said second remote station;

means for transmitting said second spread signal from the first base station over said first path to said first remote station and transmitting the second signal selectively diminished over said interference path to said second remote station;

means for receiving at said second remote station said selectively diminished second spread signal;

means for adaptively despreading the selectively diminished second signal received at the second remote station by using second despreading codes that are based on the characteristics of the received second signal over said interference path;

means for spreading a third data signal at the second remote station with second spreading codes derived from said second despreading codes based on a retrodirectivity of said interference path, the second spreading codes distributing the third data signal over a plurality of discrete tones, forming a third spread signal that is selectively diminished in said interfering path to said first base station;

and

means for transmitting said selectively diminished third spread signal from the second remote station over said interference path to said first base station.

257. The highly bandwidth-efficient communications system to optimize a multiple cell network for inter-cell interference of claim 256, wherein both the first and the second spread signals have a spectral form of a discrete multitone signal.

258. The highly bandwidth-efficient communications system to optimize a multiple cell network for inter-cell interference of claim 256, wherein said first said despreading is a multiplication of a complex number representation of the despreading codes times a complex number representation of the first spread signal.

259. The highly bandwidth-efficient communications system to optimize a multiple cell network for inter-cell interference of claim 256, wherein said first said spreading is a multiplication of a complex number representation of the second spreading codes times a complex number representation of the second data signal.

260. The highly bandwidth-efficient communications system to optimize a multiple cell network for inter-cell interference of claim 256, wherein said first said despreading determines values of complex despreading codes which are then multiplied with a complex number representation of the received signals, resulting in an estimate of the first data signal.

261. The highly bandwidth-efficient communications system to optimize a multiple cell network for inter-cell interference of claim 256, wherein the first base station has a multi-element antenna array receiving the first spread signal, further comprising:

means for despreading the first spread signal with a unitary, adaptive despreading code that is based on the characteristics of the received spread signal, where a given element of the spreading code corresponds to a given one of said multi-element antennas and a given one of said discrete tones;

whereby said despreading treats spatial and spectral samples of the first spread signal simultaneously.

262. The highly bandwidth-efficient communications system to optimize a multiple cell network for inter-cell interference of claim 256, wherein said first said despreading adaptively positions the spatial direction of receive sensitivity towards a desired signal source and diminishes receive sensitivity from interfering sources.

263. The highly bandwidth-efficient communications system to optimize a multiple cell network for inter-cell interference of claim 256, wherein the first base station has a multi-element antenna array transmitting the second spread signal, and wherein said first said spreading adaptively positions transmitted signal energy of said second spread signal towards a source of said first spread signal and adaptively diminishes transmitted signal energy towards interferers.

264. The highly bandwidth-efficient communications system to optimize a multiple cell network for inter-cell interference of claim 256, wherein said first and second signals are transmitted during consecutive parts of a time division duplex period.

265. The highly bandwidth-efficient communications system to optimize a multiple cell network for inter-cell interference of claim 256, wherein said first base station receives interference signals from interfering signal sources along with said first spread signal, further comprising:

means for adaptively reducing the interference signals by adaptively adjusting said first despreading codes to maximize the signal quality of the received signal.